Semester Exam Review Sheet
AP Physics

1. Kinematics:
   a. Motion graphs:
      i. Displacement v. time.
      ii. Velocity v. time.
      iii. Acceleration v. time.
      iv. Relationship between the three types of motion graphs.
   b. One-Dimension:
      i. Variables (units): Time (seconds: s), displacement (meters: m), initial velocity (meters per second: m/s), final velocity (m/s), acceleration (meters per second squared: m/s/s).
      ii. Equations.
      iii. Free-fall.
   c. Two-Dimensions:
      i. Same variables as One-Dimension, except in both the x- and y-directions.
      ii. Vectors:
         1. Head-to-tail addition method.
         2. Components addition method.
         3. Sine-cosine-tangent to break vector into components (triangles!).
      iii. Projectile Motion:
         1. No acceleration in x-direction.
         2. Free-fall in y-direction.
         3. Use multiple kinematics equations to find required variable(s).
         4. Break velocities into triangles to find initial or final x- and y-velocities.

2. Forces:
   a. Newton's Laws:
      i. Object in motion/at rest stays in motion/at rest unless acted upon by outside force.
      ii. Net force equals mass times the acceleration.
      iii. When one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.
   b. Variables (units): Force (Newtons: N; kg*m/s/s), mass (kg), acceleration (m/s/s).
   c. Types of forces:
      i. Applied
      ii. Friction
      iii. Weight
      iv. Tension
      v. Drag
      vi. Normal
   d. Free-body diagrams:
      i. Draw forces perpendicular to each other (break down into components if force is at an angle).
      ii. Draw all forces acting on body, unless told to ignore a certain force.
      iii. Arrows are needed to give direction of forces.

        iv. Lengths of arrows should be approximately equal to magnitude of forces. If the magnitude of the forces is unknown, then simply draw an arrow of some length.
    e. Weight:
        i. Acceleration is acceleration due to gravity: 9.8 m/s/s.
        ii. Always in the downward direction (on Earth).
    f. Friction:
        i. Coefficient of friction is the measure of how difficult it is to drag one object across another object. It has no units.
        ii. Calculated by: Force of friction = (coefficient of friction)(normal force).
    g. Normal:
        i. Always perpendicular to a surface.
        ii. Must have a surface to have a normal force.
    h. Important information:
        i. Direction of net force and acceleration is the same.
        ii. In many problems, the forces in the x- and y-directions may be analyzed independently, and then combined through another force equation or a triangle.
        iii. Friction and drag act in the direction opposite the motion of the object, parallel to the surface on which the object is moving.

3. Work, Energy, Power:
    a. Work:
        i. Variables (units): Work (Joules: J; kg*m*m/s/s), force (N; kg*m/s/s), displacement (m), theta (degrees).
        ii. Force must have some component that is in the same direction as displacement, otherwise it is not scientific work.
        iii. Equation.
    b. Kinetic Energy:
        i. The energy of movement.
        ii. Variables (units): Kinetic energy (J), mass (kg), velocity (m/s).
        iii. Equation.
    c. Potential Energy:
        i. Gravitational:
            1. Related to the height above a set zero point.
            2. We choose where the zero point is (make a convenient choice).
            3. Variables (units): Potential energy (J), mass (kg), acceleration due to gravity (m/s/s), height (m).
            4. Equation.
        ii. Spring:
            1. Stretching or compressing a spring stores some potential energy in the spring.
            2. The zero point is at the spring's natural (or unstressed or unstretched) length.
            3. Variables (units): Potential energy (J), spring constant (N/m), displacement (m).
            4. Equation.
    d. Work-Energy Theorem:
        i. Work is equal to the change in energy. Work being done *on* an object increases energy; work being done *by* an object decreases energy.

   - ii. Simple equation to begin with, but it becomes rather complicated when the kinetic and potential energies are included.
   - iii. Work may be done by non-conservative forces on a system, changing the energy of the system.
   - iv. Equation.
- e. Conservation of Energy:
   - i. Energy is conserved if we ignore non-conservative forces (friction, drag, applied).
   - ii. Initial energy is equal to final energy.
   - iii. Simple equation to begin with, but it becomes rather complicated when the kinetic and potential (both gravitational and spring) energies are included.
   - iv. Equation.
- f. Power:
   - i. Rate of work done on or by an object or system.
   - ii. Variables (units): Power (Watts: W; J/s), work (J), time (s).
   - iii. Equation.

4. Momentum:
   - a. Single-Object Momentum:
      - i. Variables (units): Momentum (kg*m/s), mass (kg), velocity (m/s).
      - ii. Equation.
   - b. Impulse-Momentum Theorem:
      - i. Variables (units): Force (N), change in time (s), momentum (kg*m/s), mass (kg), change in velocity (m/s).
      - ii. Impulse is defined as F times the change in time.
      - iii. Equation.
   - c. Conservation of Momentum:
      - i. Initial momentum is equal to the final momentum.
      - ii. More interesting if there is more than one object, so both initial momenta are added together and both final momenta are added together.
      - iii. Equation.
      - iv. Collisions:
         1. (Perfectly) Elastic:
            - a. Hit and bounce; think billiard balls.
            - b. Objects stay separate, so four terms in expanded equation.
            - c. Momentum and kinetic energy conserved.
            - d. Equation.
         2. (Perfectly) Inelastic:
            - a. Hit and stick; think two pieces of putty.
            - b. Masses combine in final case, so just one final velocity. Three terms in expanded equation.
            - c. Momentum conserved, kinetic energy is NOT conserved.
            - d. Equation.
         3. In real world, no collision is ever perfectly elastic or inelastic.

5. Circular, Satellite, and Simple Harmonic Motion, Torque, Static Equilibrium:
    a. Circular Motion:
        i. Variables (units): Force (N), radius (m), velocity (m/s), acceleration (m/s/s), period (s).
        ii. Directions of velocity and centripetal acceleration vectors.
        iii. Centripetal force vector points radially inward, and may be identified as the net force resulting from some 'real' force. Examples of 'real' forces that may be called centripetal forces are tension, static friction, normal force, etc.
        iv. Banked curves.
        v. Equations.
    b. Satellite Motion:
        i. Newton's law of universal gravitation.
        ii. Gravitation of an object near its surface equation.
        iii. Kepler's laws, qualitatively.
    c. Simple Harmonic Motion:
        i. Variables (units): Amplitude (m), period (s), frequency (Hertz: Hz), angular frequency (radians per second: rad/s), velocity (m/s), acceleration (m/s/s), length (m).
        ii. Graphing:
            1. Sines or cosines, with amplitude, wavelength, period, and frequency.
            2. From graphs and equations, it is possible to determine the maximum and minimum displacement, velocity, and acceleration, and the potential and kinetic energies.
        iii. Equations.
        iv. Mass on a Spring:
            1. A mass moving back and forth on a frictionless surface or 'hanging' in a zero gravitational field.
            2. Equations.
        v. Simple Pendulum:
            1. Small angle approximation.
            2. Equations.
    d. Torque:
        i. Angular position, velocity, and acceleration equations.
        ii. Relationship between angular kinematics equations and translational kinematics equations.
        iii. Torque equation.
    e. Static equilibrium:
        i. Net force equals zero.
        ii. Net torque equals zero.
        iii. Both cases must be met in order for the object to be in static equilibrium.

6. Electricity and Magnetism:
    a. Electrostatics:
        i. Conservation of charge.
        ii. Conductors and insulators.
        iii. Ways to charge an object:
            1. Contact.
            2. Induction.

- iv. Coulomb's Law:
  1. Variables (units): Force (N), charge (Coulombs: C), radius (m).
  2. Force is a vector.
  3. Equation.
- v. Electric field:
  1. Variables (units): Electric field (N/C), force (N), charge (C).
  2. Definition of a test charge.
  3. Equation.
  4. Electric field is a vector.
  5. Inside a conductor, E-field equals zero.
- vi. Electric field lines:
  1. They never cross.
  2. More lines means more charge.
  3. Direction is away from positive and towards negative.
- vii. Electric potential energy (analogous to gravitational potential energy).
- viii. Electric potential difference:
  1. Variables (units): Electric potential (Volts: V), electric potential energy (J), charge (C).
  2. Electric potential is a scalar.
  3. Equation.
  4. For a point charge:
     - a. Variables (units): Electric potential (V), charge (C), distance (m).
     - b. Equation.
- ix. Equipotential surfaces and their relation to the electric field.
  1. Variables (units): Electric field (N/C), electric potential (V), displacement (m).
  2. Equation.
- x. Capacitors and dielectrics:
  1. Variables (units): Capacitance (Farads: F), charge (C), electric potential (V), area (m^2), distance (m).
  2. Equations for capacitance.
  3. Dielectrics increase the capacitance of a capacitor.
  4. Energy stored in a capacitor:
     - a. Variables (units): Energy (J), capacitance (F), electric potential (V).
     - b. Equations.

b. Circuits:
- i. Electromotive force.
- ii. 'True' current versus conventional current.
  1. Variables (units): Current (Amperes: A), charge (C), time (s).
  2. Equation.
- iii. Ohm's law.
  1. Variables (units): Electric potential (V), resistance (Ohms: Ω), current (A).
  2. Equation.
- iv. Resistance and resistivity:
  1. Variables (units): Resistivity [ρ] (Ω*m), length (m), area (m^2).
  2. Equation.

v. Electric power:
  1. Variables (units): Power (W), electric potential (V), current (A), resistance (Ω).
  2. Equations.
  3. Total or for each individual resistor.

vi. Wiring parts of circuits:
  1. Series:
    a. Equivalent resistance determined by adding resistor values.
    b. Equivalent capacitance determined by 'one-over' equation.
  2. Parallel:
    a. Equivalent resistance determined by 'one-over' equation.
    b. Equivalent capacitance determined by adding capacitor values.
  3. Equivalence resistance/capacitance:
    a. Start from the outside piece and work inwards.
    b. Determine how each part is connected.

vii. Internal resistance.

viii. Kirchoff's rules:
  1. Junction rule (current rule).
  2. Loop rule (voltage rule).

ix. Measurement of current and voltage.

x. RC circuits:
  1. Time constant.
  2. Charging equation:
    a. Variables (units): Charge (C), time (s), resistance (Ω), capacitance (F).
    b. Equation.
  3. Discharging equation:
    a. Variables (units): Charge (C), time (s), resistance (Ω), capacitance (F).
    b. Equation.

7. Magnetism and Electromagnetism:
  a. Magnetism:
    i. Only dipoles exist.
    ii. Right-hand rule #1:
      1. Determines the direction of the velocity (first finger), magnetic field (middle finger), and magnetic force (thumb) for positive charge.
      2. Special cases when angles at maximum or minimum.
    iii. Definition of magnetic field:
      1. Variables (units): Magnetic field (Tesla: T), force (N), charge (C), velocity (m/s), angle (degrees).
      2. Equation.
    iv. Mass spectrometer.
    v. Force on a current in a magnetic field:
      1. Variables (units): Force (N), current (A), length (m), magnetic field (T), angle (degrees).
      2. Equation.
      3. Special cases when angles maximum or minimum.

vi. Magnetic fields produced by currents:
1. Right-hand rule #2: Thumb points in direction of current, fingers curl in direction of magnetic field.
2. Variables (units): Magnetic field (T), current (A), distance (m).
3. Equation.
4. Loop of wire:
   a. Variables (units): Number of turns (unitless), current (A), radius (m).
   b. Equation.
5. Solenoid: multiple loops of wire; magnetic field uniform inside loop.

b. Electromagnetic Induction:
i. Induced emf and induced current.
ii. Motional emf:
1. Variables (units): Electromotive force (V), velocity (m/s), magnetic field (T), length (m).
2. Equation: Velocity, magnetic field, and length are all mutually perpendicular.
3. Used to generate electricity.

iii. Magnetic flux:
1. Variables (units): Magnetic flux [Φ] (Webers: Wb), magnetic field (T), area (m^2), angle (degrees).
2. Equation.
3. Understand the direction of the angle.

iv. Faraday's law and Lenz's law.
1. Variables (units): Electromotive force (V), number of turns (unitless), magnetic flux (Wb), time (s).
2. Equation.
3. Be very careful with directions of variables because it gets confusing very quickly.